

IN THE SPECIFICATION

Please replace the paragraphs beginning at page 2, line 26, through page 24, line 11, with the following rewritten paragraphs:

The invention is characterized in that a functional device is sandwiched by a holding member, and a composite body is formed. The present invention has such a configuration provides a simple and effective method wherein, once a composite body is formed, there is only a small change in straightness under loads and in the operating environment (changes in temperature).

The present invention is characterized in that a functional device is caulked by a holding member to form a composite body. The invention arranged in the aforementioned manner provides a simple and effective method wherein, once a composite body is formed; there is only a small change in straightness under loads and in the operating environment (changes in temperature).

The invention is characterized in that a functional device is sandwiched by a holding member, and a composite body is formed through plastic deformation of the functional device. The present invention having such a configuration provides an effective method wherein, once a composite body is formed, there is only a small change in straightness under loads and in the operating environment (changes in temperature). Furthermore, improved engagement between the functional device and holding member is ensured by plastic deformation. Since this engaged portion serves as a guide, superb straightness can be maintained even if misalignment is caused by linear expansion coefficient in the operating environment (changes in temperature).

The invention is characterized in that a functional device is caulked by a holding

member, and a composite body is formed through plastic deformation of the functional device. The invention having such a configuration provides an effective method wherein, once a composite body is formed, there is only a small change in straightness under loads and in the operating environment (changes in temperature). Furthermore, improved engagement between the functional device and holding member is ensured by plastic deformation. Since this engaged portion serves as a guide, superb straightness can be maintained even if misalignment is caused by linear expansion coefficient in the operating environment (changes in temperature).

The invention is characterized in that a functional device is press-fitted into a holding member, and a composite body is formed through plastic deformation of the functional device. The invention having such a configuration provides an effective method wherein, once a composite body is formed, there is only a small change in straightness under loads and in the operating environment (changes in temperature). Furthermore, improved engagement between the functional device and holding member is ensured by plastic deformation. Since this engaged portion serves as a guide, superb straightness can be maintained even if misalignment is caused by linear expansion coefficient in the operating environment (changes in temperature).

The invention is characterized in that a holding member or functional device is subjected to elastic deformation and are fixed together. Then the functional device is heated and is subjected to plastic deformation to reduce the stress between two components, thereby allowing the holding member and functional device to slide-fit with each other. According to the invention having such a configuration, the holding member is subjected to elastic deformation first, and is fixed to the functional device. Then the functional device is heated

in excess of thermal deformation temperature and is softened, and the installation portion of the functional device is deformed by the resilient restoring force of the holding member. Furthermore, the functional device is solidified by cooling, and a clearance is formed due to the difference in shrinkage of two components, whereby a composite body is formed. Here, the resilient restoring force of the holding member is employed to allow slide-fitting between the functional device and holding member. As a result, direct force is generated between two components, thereby ensuring slide-fitting of excellent engagement. Furthermore, no external force is used. This feature provides a simple configuration and low cost of the apparatus.

The invention is characterized in that a holding member is subjected to elastic deformation to sandwich a functional device. The present invention having such a configuration allows the holding member to sandwich the functional device by subjecting it to elastic deformation.

The invention is characterized in that a holding member is subjected to elastic deformation and a functional device is staked. The invention having such a configuration allows the holding member to be subjected to elastic deformation and the functional device to be caulked.

The invention is characterized in that a functional device is subjected to elastic deformation and is press-fit into a holding member. The invention having such a configuration allows the functional device to be subjected to elastic deformation and to be press-fit into the holding member.

The invention is characterized in that the steps of holding a functional device by a holding member to be formed into a composite body; elastic-deforming the holding member

or functional device to fix the holding member and functional device together, heating the functional device, and plastic-deforming to reduce stress between two components, thereby allowing the holding member and functional device to slide-fit with each other, and transfer of the shape of molding die functional surface are carried out in one and the same process. The invention having such a configuration allows the shape of the molding die functional surface to be transferred in one and the same process.

The invention is characterized in that part of a functional device assembled with a holding member is formed in a rugged shape. According to the invention having such a configuration, slide-fitting force (frictional force) can be adjusted in a desired manner by changing the contact area between the functional device and holding member.

The invention is characterized in that part of a functional device assembled with a holding member is designed in a symmetrical configuration. The invention having such a configuration provides a composite optical component with small curvature because temperature distribution is symmetrical during the molding process.

The invention is characterized in that the aforementioned functional device is an optical device wherein one or more lenses, prisms or mirrors are arranged. The invention having such a configuration allows a thin-walled and long-sized optical device to be configured in a composite body most effectively.

(Second Invention)

The invention is characterized in that a composite optical component comprises an optical component and an enclosure of different materials slidably combined with each other to ensure that the sliding resistance between the aforementioned optical component and enclosure will be  $F \leq a/b \times S \times E$ . Here "S" in the above expression denotes the sectional

area of the optical unit of the optical component, "E" shows a longitudinal elastic coefficient of the material of the optical component, and "a" represents a permissible difference of linear expansion (permissible distortion) due to changes of temperature per length b of the optical components with respect to the enclosure. The invention having such a configuration ensures the optical component and enclosure to be firmly held in position without any play at all because the sliding resistance between the aforementioned optical component and enclosure is  $F \leq a/b \times S \times E$ . This prevents the optical component from being tilted toward the enclosure, deformed or misaligned due to play.

Assuming, on the other hand, that the sectional area of the optical unit of the optical component is S, and the modulus of elasticity of optical component material (longitudinal elastic coefficient) is E, force F which gives distortion of "a" per length "b" of optical component is calculated. Then one gets the aforementioned force  $F = a/b \times S \times E$ . If the difference in linear expansion (difference in linear expansion per unit length) between the optical component and enclosure due to changes in temperature has reached the level of the aforementioned "a", and the optical component is locked to the enclosure, then only the internal distortion of the optical component reaches the permissible limit in terms of maintaining the optical characteristics due to the aforementioned force F because the enclosure as a reinforcing member is stronger. The optical performance of the optical component is reduced in excess of the permissible limit by this internal distortion. So the optical component must be made to slide with respect to the enclosure to avoid the aforementioned internal distortion due to the difference in thermal expansion. If this difference in expansion is to be removed by sliding, the sliding resistance of the sliding surface must be equal to or lower than the value F. To put it more specifically by giving an

example: If the sectional area  $S$  of the lens unit =  $16\text{mm}^2$ , the modulus of elasticity of the plastic  $E = 0.25 \times 10^{10} \text{ [Pa]}$ , and  $a/b = 0.001$  are substituted into the equation,  $F = 4\text{[N]}$  (N stands for "Newton" denoting a unit of force) is obtained. The sliding resistance below this value is required.

The lower limit value requiring the aforementioned frictional resistance  $F$  is a bonding force necessary to ensure a stable maintenance of the optical component in the enclosure against vibration or the like. This is much smaller than the upper limit value  $F$  of the aforementioned sliding resistance. It varies widely according to the type of each composite optical component and the type of the optical equipment where composite optical components are used. Accordingly, the lower limit value of the aforementioned sliding resistance must be determined for each case.

The invention is characterized in that, in a composite optical component comprising an optical component and an enclosure of different materials slidably combined with each other, the optical component and enclosure are fixed at one position, and the sliding resistance of the sliding portions in other areas is kept below  $F = a/b \times S \times E$ . The invention having such a configuration ensures that misalignment does not occur to the optical component with respect to the enclosure, despite repeated processes of expansion and shrinkage due to changes in temperature, since the optical component and enclosure are fixed at one position. Furthermore, the sliding resistance of the sliding portions in other areas is kept below  $F = a/b \times S \times E$ . Thus, similarly to the cases of the aforementioned solutions, the difference in thermal expansion between the optical components and enclosure due to changes in temperature is eliminated by the sliding between the optical component and enclosure; therefore, internal distortion does not occur to the optical component due to the

aforementioned difference in thermal expansion.

The invention is characterized in that, in a composite optical component comprising an optical component and an enclosure slidably combined with each other, a sliding groove is formed on either of the sliding surfaces between the optical component and enclosure, and a contact protrusion is formed on the other sliding surface. It is fit into the aforementioned sliding groove, and is connected by mechanical contact to permit sliding only in one direction. The invention having such a configuration allows the optical component to slide in a straight line with respect to the enclosure in the direction of the sliding groove (in the longitudinal direction), because a sliding groove is formed on either of the sliding surfaces between the optical component and enclosure, and a contact protrusion is formed on the other sliding surface; furthermore, it is fitted into the aforementioned sliding groove, and is connected by mechanical contact so that it can slide only in one direction. In the direction at a right angle to the sliding groove (lateral direction), the optical component is held by the enclosure by engagement between the contact protrusion and the aforementioned sliding groove, so no misalignment occurs in the lateral direction with respect to the enclosure.

The invention is characterized in that a contact protrusion is formed on either of the sliding surfaces between the optical component and enclosure of the aforementioned composite optical component, and the sliding surface is subjected to mechanical contact due to elastic force caused by elastic deformation of the aforementioned contact protrusion so that sliding resistance occurs. This sliding resistance is kept not to exceed the aforementioned sliding resistance. The invention having such a configuration allows the sliding resistance to be controlled to a specified value with comparative ease by adjusting the height of the contact protrusion, because the sliding resistance of the aforementioned sliding surface is produced

by the elastic force caused by deformation of the aforementioned contact protrusion, with the aforementioned optical component fitted into the enclosure.

The invention is characterized in that, in the aforementioned composite optical component, the rib of the optical component is sandwiched and slidably held by the holding part of the enclosure in such a way that the clearance between the aforementioned rib and the aforementioned holding part does not exceed 50  $\mu\text{m}$ . The invention having such a configuration provides the following advantage: If there is a great clearance between the slide-fitted portions of the rib of the optical component and the holding part of the enclosure, a local tilt or curvature will occur to the optical component, and this will affect optical characteristics. However, if the aforementioned clearance is kept at 50  $\mu\text{m}$  or less, the aforementioned local tilt and curvature will be kept within the permissible limit. Thus, optical characteristics of the optical component are not affected by the local tilt and curvature.

The invention is characterized in that the aforementioned optical components and enclosure are formed into long-sized tabular members.

The invention is characterized in that the aforementioned optical component is made of resin material, and the enclosure is made of metallic member.

The invention is characterized in that the optical component is made of a glass member or a composite material of resin and glass member.

The invention is characterized in that both the optical component and enclosure are made of resin.

The invention is characterized in that the aforementioned enclosure is made of ceramic material.



The invention is characterized in that the aforementioned optical component is a single optical member in which multiple lenses, prisms and mirrors are arrayed, and the edge of the aforementioned optical component is slidably held by the holding part of the enclosure.

The invention is characterized in that the composite optical component is provided on an optical print head, image forming apparatus or image reading apparatus.

(Third Invention)

The invention is characterized by a composite optical component wherein an optical functional device is held by a holding member for reinforcement, and the aforementioned optical functional device and holding member are processed to become integrated into one body within the mold, and are slide-fitted with each other. In the composite optical component having such a configuration, the optical functional device is firmly held with respect to the holding member without any play, but these two members are not integrally locked by the holding part over the entire length. If the optical functional device is subjected to thermal expansion due to changes in temperature during the use and tends to expand with respect to the holding member, then the optical functional device slides with respect to the holding member against the holding force of the holding part, and the internal distortion of the optical functional device due to thermal expansion is eliminated. Thus, straightness is not deteriorated despite changes in temperature, and high optical performance is ensured.

The holding member is placed outside ("outserted") and is processed into one integrally molded product using a mold. So there is no deterioration of precision due to assembling error, unlike the case where the optical functional device and holding member are molded to a high precision, and are then assembled into a composite body (e.g., the aforementioned art for comparison). Thus, this simple method provides a composite optical

component with a high degree of straightness at a low cost.

The invention is characterized by a composite optical component wherein the contact surfaces on the aforementioned slide-fitted portions of the aforementioned optical functional device and holding member are partly fixed with each other, and remaining contact surfaces are slide-fitted. The composite optical component having such a configuration permits the entire optical functional device to move with respect to the holding member and ensures misalignment to be avoided, because the optical functional device and holding member are partly fixed with each other. Further, the optical functional device is fixed at the position serving as a reference with respect to the holding member, so the composite optical component provides a high degree of performance as designed.

The invention is characterized by a composite optical component wherein the contact surfaces on the aforementioned slide-fitted portions of the aforementioned optical functional device and holding member are partly assembled in a rugged shape or fixed with each other by bonding. The composite optical component having such a configuration provides a higher degree of optical characteristics because the reference position of the optical functional device is firmly fixed at a more accurate position with respect to the holding member.

The invention is characterized by a composite optical component wherein a groove is formed on part of the aforementioned holding member or optical functional device, and the protrusion of the optical functional device or holding member is slidably engaged into the aforementioned groove of the holding member or optical functional device in a composite body. The composite optical component having such a configuration provides a high degree of optical performance because sliding is performed only in the permitted direction, independently of the thermal expansion of the optical functional device.

The invention is characterized by a composite optical component wherein the straightness of the contact surface of the holding member slidably in contact with the aforementioned optical functional device is 10 percent or more lower than that required of the optical function unit of the optical functional device. The composite optical component having such a configuration allows use of a low-cost holding member with a low degree of straightness, and is therefore a low-cost and high-function composite optical component.

The invention is characterized by the composite optical component wherein the longitudinal sliding resistance of slide-fitted portions of the aforementioned optical functional device and holding member does not exceed  $\Delta F = a \times S \times E$  per 1mm in the longitudinal direction of the optical functional device, where "a" denotes the permissible elongation of the optical functional device due to thermal expansion in the optical system (the difference in thermal expansion of the holding member and optical functional device per unit length), S represents the sectional area of the function unit of the optical functional device, and E shows a modulus of elasticity (longitudinal elastic coefficient) of the material of the optical functional device. In the composite optical component having such a configuration, the holding member and optical function device are slide-fitted with each other without excessive sliding resistance; therefore, the optical functional device is not subjected to internal distortion due to thermal expansion or the like. Accordingly, excellent straightness of the optical functional device is not deteriorated by thermal expansion or the like.

The invention is characterized by a composite optical component wherein the portion of the aforementioned optical functional device in contact with the holding member is composed of a resin material. The composite optical component having such a configuration is made of the resin material characterized by excellent mold-ability, so it has a slide-fitted

surface easily molded. It is a composite optical component characterized by low cost and excellent functions

The invention is characterized by a composite optical component wherein the aforementioned holding member is made of metallic material. The composite optical component having such a configuration provides a high-strength composite optical component because it uses a holding member made of a metallic material much stronger than resin. Accordingly, even under the circumstances where deflection is given to the composite optical component the aforementioned composite optical component maintains excellent optical characteristics.

The invention is characterized by a composite optical component wherein the aforementioned holding member is obtained by stamping the product molded by aluminum-extrusion or extrusion. The composite optical component having such a configuration is characterized by light weight, processing ease and low cost because the product molded by aluminum-extrusion is used as a holding member.

The invention is characterized by a composite optical component wherein the aforementioned holding member is made of stamped sheet metal. The composite optical component having such a configuration is a high-strength and low-cost composite optical component because the holding member is made of stamped sheet metal characterized by excellent processability.

The invention is characterized by a composite optical component wherein the aforementioned holding member is made of resin material reinforced with glass fiber. The composite optical component having such a configuration is a low-cost and high-function composite optical component because the holding member is made of resin material

reinforced with glass fiber characterized by excellent mass production.

The invention is characterized by a composite optical component wherein the function unit of the aforementioned optical functional device is made of resin material. The composite optical component having such a configuration is characterized by easy mold-ability of optical functional surfaces and high-precision optical functional surfaces because the holding member is made of resin material characterized by excellent moldability.

The invention is characterized by a method for manufacturing a composite optical component wherein the aforementioned optical function device and holding member are processed into one integral body by a mold. It is further characterized by a method for manufacturing the composite optical component wherein transfer of the optical function surface of the molding die for the aforementioned optical functional device and slide-fitting between the optical functional device and holding member are provided in one and same molding step. The method for manufacturing the composite optical component having such a configuration provides a composite optical component of high straightness at a low cost, as compared to the case where the holding member and optical functional device are separately processed and are assembled into one piece.

The invention is characterized by a method for manufacturing a composite optical component wherein transfer of the optical function surface of the molding die for the aforementioned optical functional device and slide-fitting between the optical functional device and holding member are provided in one and same molding step using different mechanisms. The manufacturing method configured in this manner provides slide-fitting surfaces having a predetermined fixing force with regard to the slide-fitted portions between the holding member and optical functional device. It provides a composite optical functional

device of high precision and high straightness at a low cost.

The invention is characterized by a method for manufacturing a composite optical component wherein the optical function surface of the molding die is transferred to a spare molded product of the optical functional device after the aforementioned spare molded product is inserted into the aforementioned holding member. The manufacturing method configured in this manner considerably reduces the time of molding the composite optical component having a high-precision optical function surface using the optical functional device.

The invention is characterized by a method for manufacturing a composite optical component wherein the aforementioned spare molded product is made of resin material, and the optical functional surface of the molding die is transferred by moving the molding die having the shape of optical functional surface, and applying pressure to the optical functional surface of the aforementioned spare molded product. The manufacturing method configured in this manner provides a reliable way of forming a high-precision optical functional surface of the optical functional device, and a high-precision and low-cost composite optical component.

The invention is characterized by a method for manufacturing a composite optical component wherein pressure is applied to the functional surface-compatible portion of the aforementioned spare molded product and the vicinity thereof, after having been heated in excess of the glass transition point of the resin material being used. The manufacturing method configured in this manner provides a reliable way for stable formation of a higher-precision optical functional surface, and provides a high-precision and low-cost composite optical component.

The invention is characterized by a method for manufacturing a composite optical component wherein the shape of the aforementioned spare molded product is close to the final shape of the optical functional device. The manufacturing method configured in this manner allows short-time molding of a molded product with high-precision optical functional surface, and provides a low-cost and high-precision composite optical component.

The invention is characterized by a method for manufacturing a composite optical component wherein the aforementioned spare molded product is an injection molded product. The manufacturing method configured in this manner allows low-cost volume production of a spare molding component having a shape close to the final one, and hence permits a low-cost and high-precision composite optical component to be manufactured.

The invention is characterized by a method for manufacturing a composite optical component wherein heat and pressure are applied to several positions in the vicinity of the contact surface of the aforementioned optical functional device in contact with the aforementioned holding member to make wave-shaped deformation, thereby ensuring slide-fitting between the aforementioned optical functional device and holding part of the aforementioned holding member. The manufacturing method configured in this manner allows easy formation of slide-fitted portions between the optical functional device and the holding member having a predetermined fixing force, and hence permits easy production of a low-cost and high-precision composite optical component.

The invention is characterized by a method for manufacturing a composite optical component wherein external force is applied to the vicinity of the contact surface of the aforementioned optical functional device in contact with the holding member to ensure that the optical functional device is slide-fitted to the holding part of the holding member. The

manufacturing method configured in this manner allows easy formation of slide-fitted portions between the optical functional device and the holding member having a predetermined fixing force, and hence permits easy production of a high-precision and low-cost composite component.

The invention is characterized by a method for manufacturing a composite optical component wherein external force is applied to the vicinity of the contact surface of the aforementioned holding member in contact with the optical functional device to ensure that the optical functional device is slide-fitted to the holding part of the holding member. The manufacturing method configured in this manner provides a reliable way of deforming the resin to form a slide-fitting part between the optical functional device and holding member, and allows a high-precision and low-cost composite optical component to be manufactured.

The invention is characterized by a method for manufacturing a composite optical component wherein the resin moved by application of pressure to the functional surface of the aforementioned optical functional device or application of the aforementioned external force to other positions than the functional surface is brought into mechanical contact with the internal side surface of the holding member in such a way that the optical functional device is slide-fitted to the holding part of the holding member. The manufacturing method configured in this manner provides a reliable way of forming slide-fitted portions of a greater contact surface area between the optical functional device and holding member, and hence allows a high-precision and low-cost composite optical component to be manufactured.

The invention is characterized by a method for manufacturing a composite optical component wherein, while the aforementioned optical functional device is kept in mechanical contact with the internal side surface of the holding part of the holding member by molding



for integration with the holding member, the holding part of the aforementioned holding member is supported from the outside, thereby preventing the aforementioned holding part from being deformed. The manufacturing method configured in this manner prevents the holding member from being deformed in integration molding step, and provides a low-cost composite optical component characterized by a high degree of straightness.

The invention is characterized by a method for manufacturing a composite optical component wherein at least a part in the vicinity of the contact surface of the aforementioned optical functional device in contact with the holding member is heated in excess of the thermal deformation temperature of the material resin. The manufacturing method configured in this manner allows easy formation of slide-fitted portions between the optical functional device and the holding member having a predetermined fixing force, and hence permits production of a high-performance composite optical component at a reduced cost.

The invention is characterized by a composite optical component wherein an optical functional device is held by a holding member for reinforcement, wherein the optical functional device and holding member are processed to become integrated into one body within the mold, and are slide-fitted with each other, where the composite optical component is manufactured wherein transfer of the optical function surface of the molding die for the optical functional device and slide-fitting between the optical functional device and holding member are provided in one and same molding step. The composite optical component configured in this manner is based on the manufacturing method ensuring a low cost and high degree of functions, so it is a low cost product, despite high degree of functions.

The invention is characterized by a long-sized composite optical component wherein the longitudinal length is 50mm or more. The composite optical component according to the

invention configured in this manner is a low-cost composite optical component characterized by a high degree of straightness and function, despite a long-sized configuration.

The invention is characterized by a composite optical component wherein the optical functional device comprises lenses, prisms or mirrors arranged in multiple numbers. The composite optical component configured in this manner is a low-cost component characterized by high precision and a high degree of straightness, although it is a long-sized component consisting of multiple optical devices requiring high precision.

The invention is characterized by an optical writing unit equipped with a composite optical component. The optical writing unit configured in this manner is a high-performance and low-cost optical writing unit because it is equipped with a composite optical component.

The invention is characterized by an optical reading unit equipped with a composite optical component. The optical reading unit configured in this manner is a high-performance and low-cost optical reading unit because it is equipped with a composite optical component.

The invention is characterized an image forming apparatus equipped with an optical writing unit. The image forming apparatus configured in this manner is a high-picture quality and low-cost image forming apparatus since it is equipped with an optical writing unit.

The invention is characterized by an image reading apparatus equipped with the optical reading unit. The image reading apparatus configured in this manner is a high resolution and low-cost image reading apparatus because it is equipped with the optical reading unit.